



# **Advanced Telescopes & Observatories Capability Roadmap Status Presentation to Search for Earth-like Planet Strategic Panel**

**Lee Feinberg / NASA GSFC  
Howard MacEwen (SRS/NRO)  
Feb 15th, 2005**



## Intro



- **The Advanced Telescope and Observatory Capability Roadmap Panel is preparing for a Presentation to the National Academy of Engineering/NRC**
  - **Draft Roadmaps Due Next Week**
  - **Presentation on March 15<sup>th</sup>**
- **The following slides are taken from the introductory portion of the Draft NRC Presentation**
  - **Will go through with emphasis on items of interest to Search for Earth-like Planet Strategic Panel**
- **The additional detailed roadmaps are still in-process**



## ATO Capability Roadmap Team



### Co-Chairs

**NASA: Lee Feinberg, Goddard Space Flight Center**

**External: Howard MacEwen, SRS Technologies (NRO Rep.)**

### Team Members

#### Government

**Jim Breckinridge, JPL**

**Pete Jones, AFRL**

**David Tratt, JPL/ESTO**

**H. Philip Stahl, MSFC**

#### Industry

**Jim Crocker, LMCO**

**Ron Polidan, NGST**

**Gary Matthews, ITT**

**Mark Stier, Goodrich**

**Jim Oschmann, Ball Aer.**

#### Academia

**Jim Fienup, UofR**

**Dave Miller, MIT**

**Jim Burge, UAz**

**Dan Inman, Va Tech**

#### Center Reps

**John Hong, JPL**

**Scott Smith, MSFC**

**Ray Boucarut, GSFC**

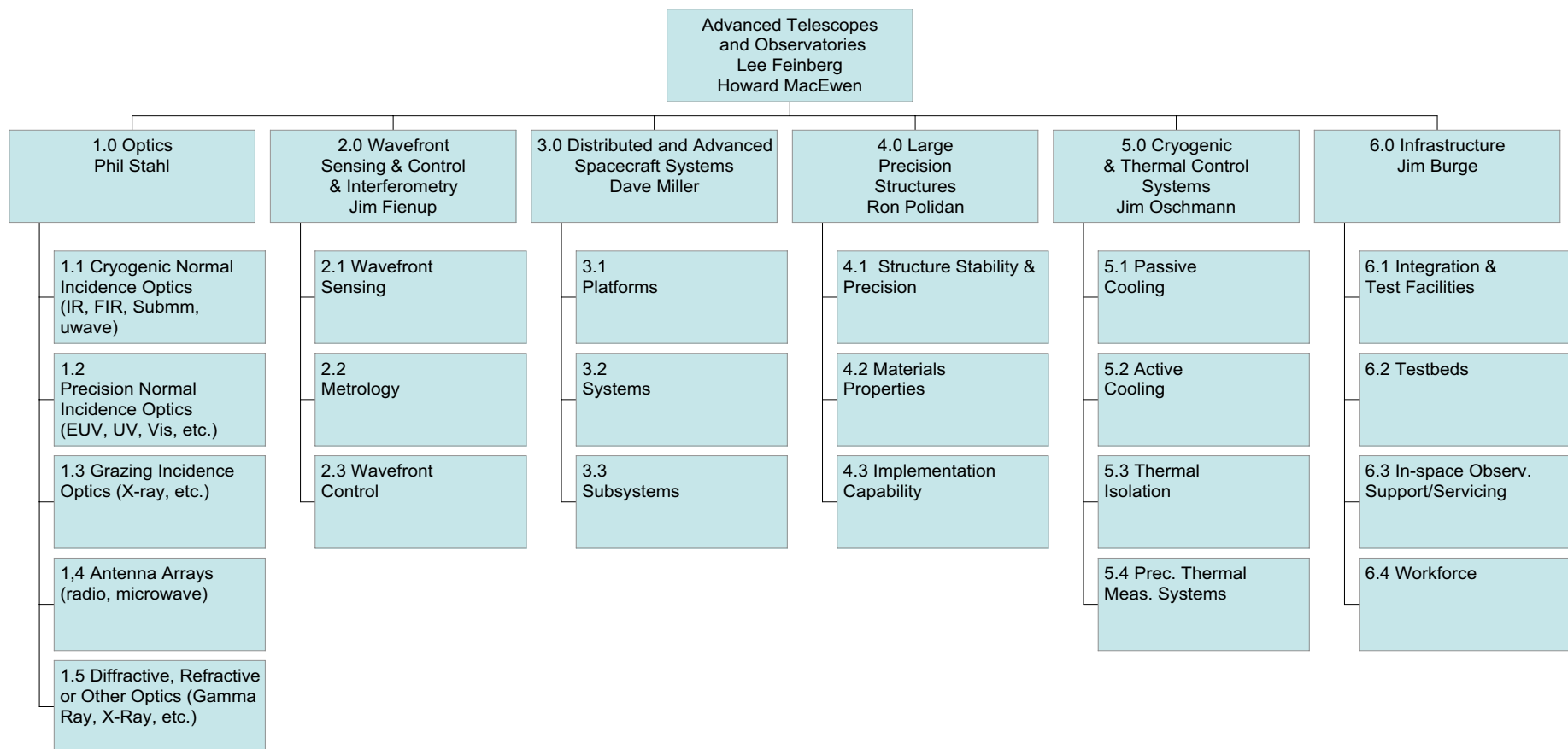
#### Coordinators

**Directorate: Harley Thronson, HQ**

**APIO: Dan Coulter, JPL**



# ATO Capability Breakdown Structure





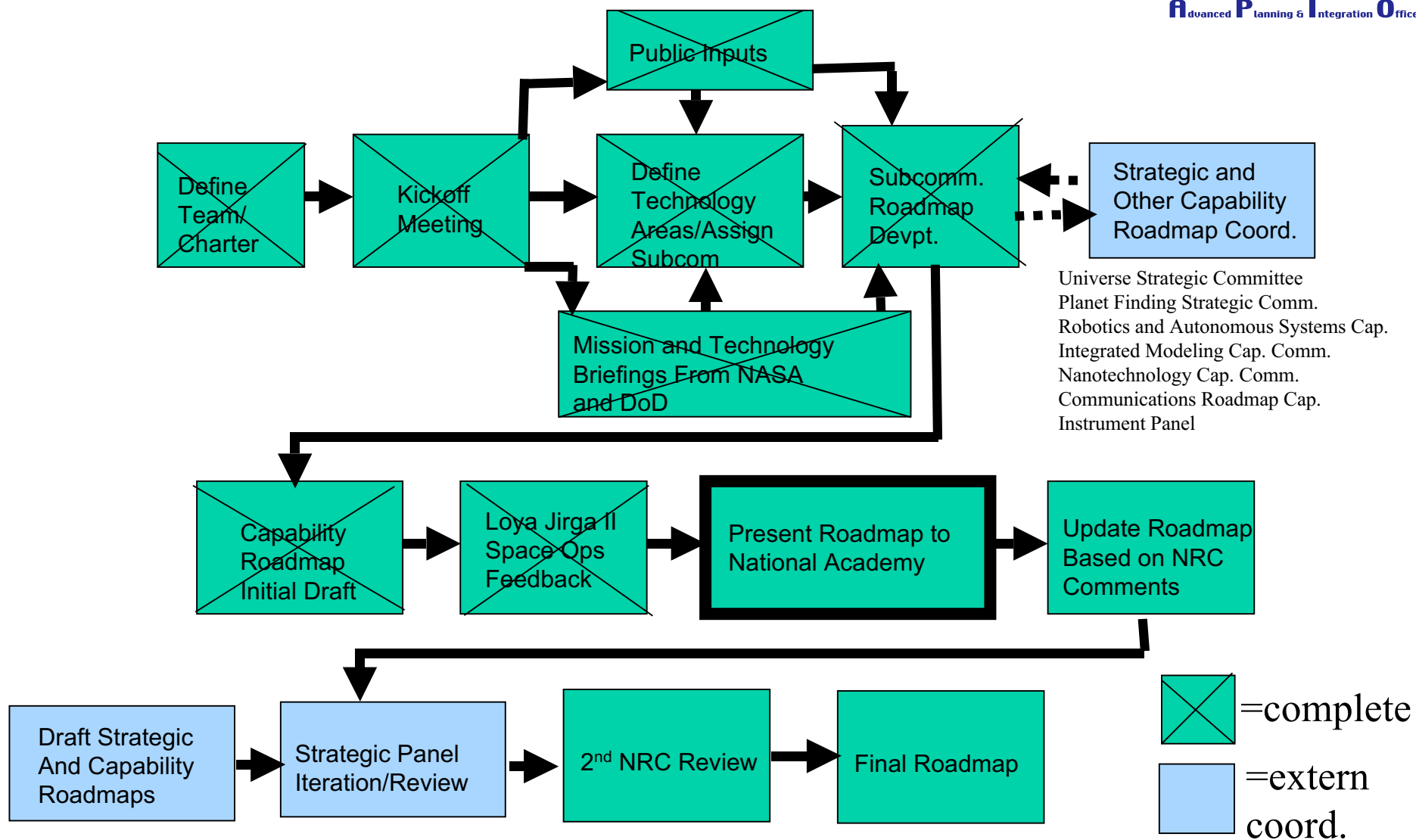
## Traceability of ATO Drivers



- **Presidential vision “Conduct advanced telescope searches for Earth-like planets and habitable environments around other stars”**
- **Aldridge Report: “The Commission finds implementing the space exploration vision will be enabled by scientific knowledge, and will enable compelling scientific opportunities to study Earth and its environs, the solar system, other planetary systems and the universe”, Aldridge Report**
- **National Academy Astronomy and Astrophysics Decadal Survey**
  - **High Priority Major (Space) Initiatives in Priority Order:**
    - James Webb Space Telescope (formerly NGST)
    - Constellation X Observatory
    - Terrestrial Planet Finder/Single Aperture Far Infrared Observatory
  - **Moderate (Space) Initiatives**
    - GLAST
    - LISA
    - Solar Dynamics Observatory
    - EXIST (Black Hole Finder)
- **Reference mission list provided by Science Directorate and being reviewed by strategic roadmapping**
  - Includes Earth-Sun System priorities



# ATO Roadmap Process









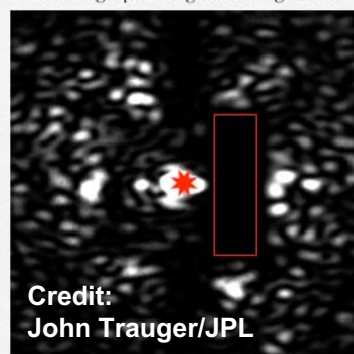
## Telescopes in the Future: Not Just Bigger, But Better



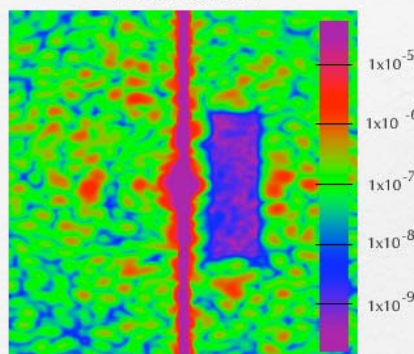
- Future Advanced Telescopes and Observatories won't just be bigger but also *better*. For example, if we want to study an extra-solar earth-like planet in the visible, then the amount of *contrast* of the system (a measure of how well an optical system can block a bright star) is critical

### Laboratory testbed demonstration of high contrast imaging

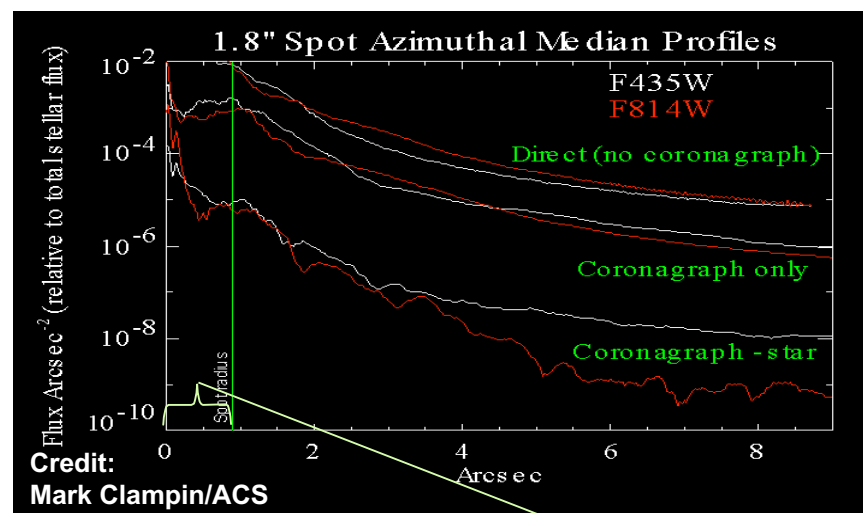
Coronagraph image and target box



Testbed Contrast



This laboratory coronagraph image was obtained with a linear occulting mask in December 2004. Inner boundary of the target box is 4 Airy radii to the right of the suppressed 'star' image (star position is indicated by the star-shaped fiducial). Average intensity of background speckles in the target box is fainter than the 'star' by a factor of  $9 \times 10^{-10}$  in 785 nm narrowband (laser) light. Contrast is stable to about  $5 \times 10^{-11}$  / hour with the DM actuator settings maintained open-loop at constant voltages.



Earth-like planets  
are <1 arcsec from star  
and about .1 arcsec wide

- Contrast** is driven by the smoothness of the mirrors, the stability of the telescope system, and the basic architecture, optics and algorithms used to block the bright star and filter through the dim planet.
- Black Hole X-ray systems and gravity wave systems also need “better” optical systems (higher precision). For FIR and Submm systems, better usually means colder.





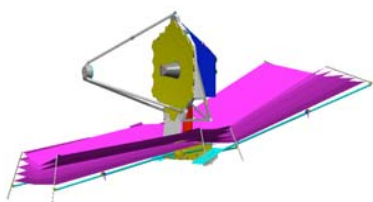
# ATO Current vs. Future Capabilities



## Operational



**Hubble Space Telescope**  
2.4m monolith



**James Webb Space Telescope**



**TPF-C**  
4x8 meter primary  
Prec. Optics/occulters  
Deformable mirrors/  
Advanced Algorithms  
Stable structures/



**TPF-I**  
Nulling Interferometry  
Formation Flying



**SAFIR:**  
FIR Observatory  
10-meter FIR Telescope  
5-Kelvin Mirrors  
Active/Passive Cooling



**Constellation X:**  
X-ray Spectroscopy  
Four identical 1 meter  
X-ray Telescopes  
Cryocooled detectors



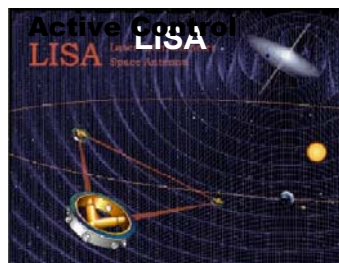
**Spitzer Space Telescope**  
.8m Cryogenic telescope

6.5m Segmented Telescope  
Wavefront Sensing/Control  
Sunshade Pass. Cooling to 35K  
Large Deployables



**SIM: Astrometry**

**Precision Metrology Interferometry**  
Stable lasers



**LISA**  
Gravity Wave Detection:  
3 space craft constellation.  
Sub nm displacements  
measured by  
laser/interferometry  
Micro-thrusters



**Chandra X-ray Telescope**

Sample Long Term Missions  
That Drive Technology

**Stellar Imager:**  
UV Interferometer  
Formation Flying

**Life Finder And Planet Imager:**  
>50m coronagraph+  
Formation Flying Interferometer

**FIR Interferometer**  
1 KM Baseline

**Black Hole Imager:**  
X-ray F.F. Interf.

**Large UV-Optical:**  
10+ meters Segmented Aperture

**InSAR Concept**  
**GEO/MEO InSAR/Soil Moisture**

Current

In Development

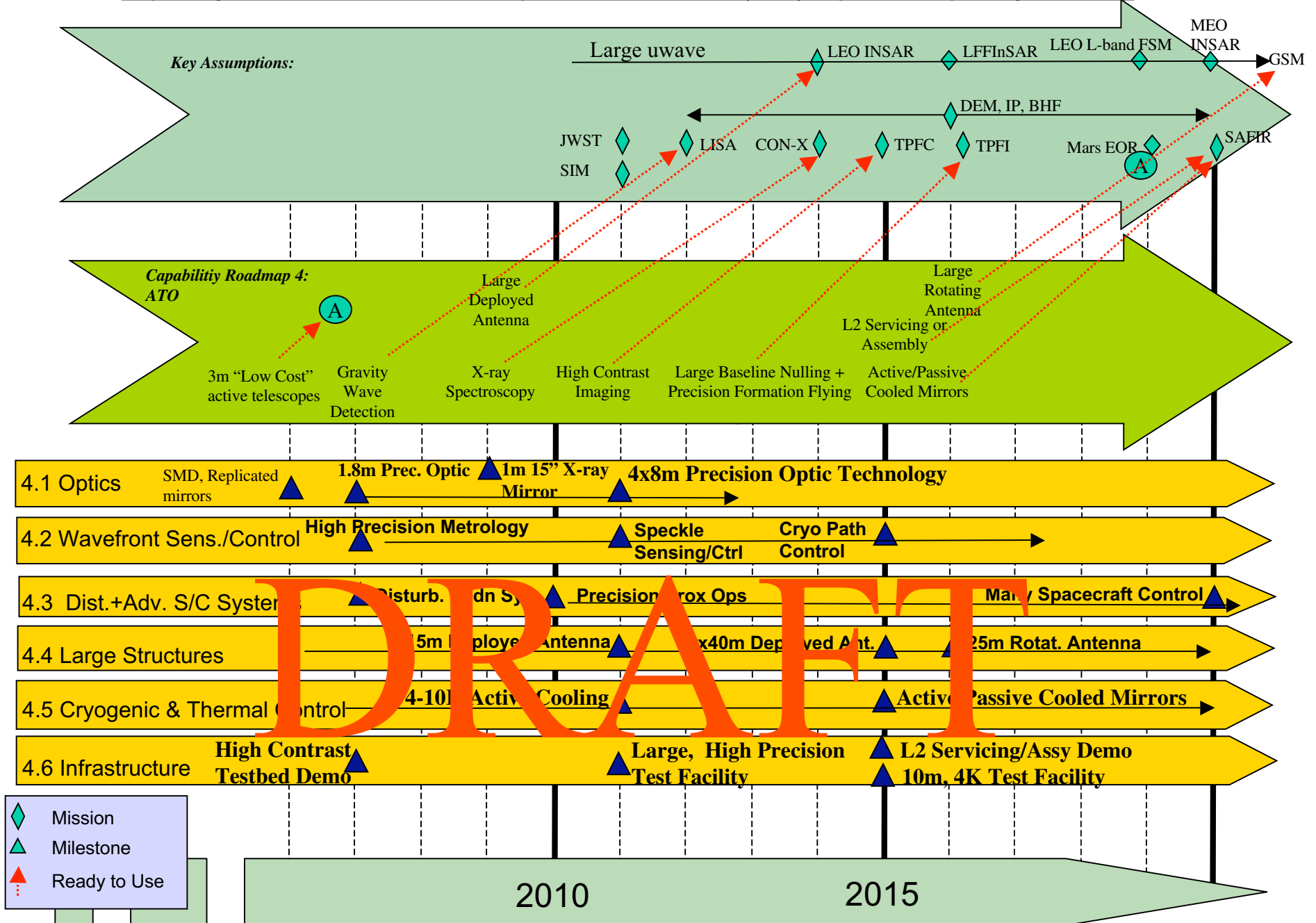
2005-2015

2015-2025

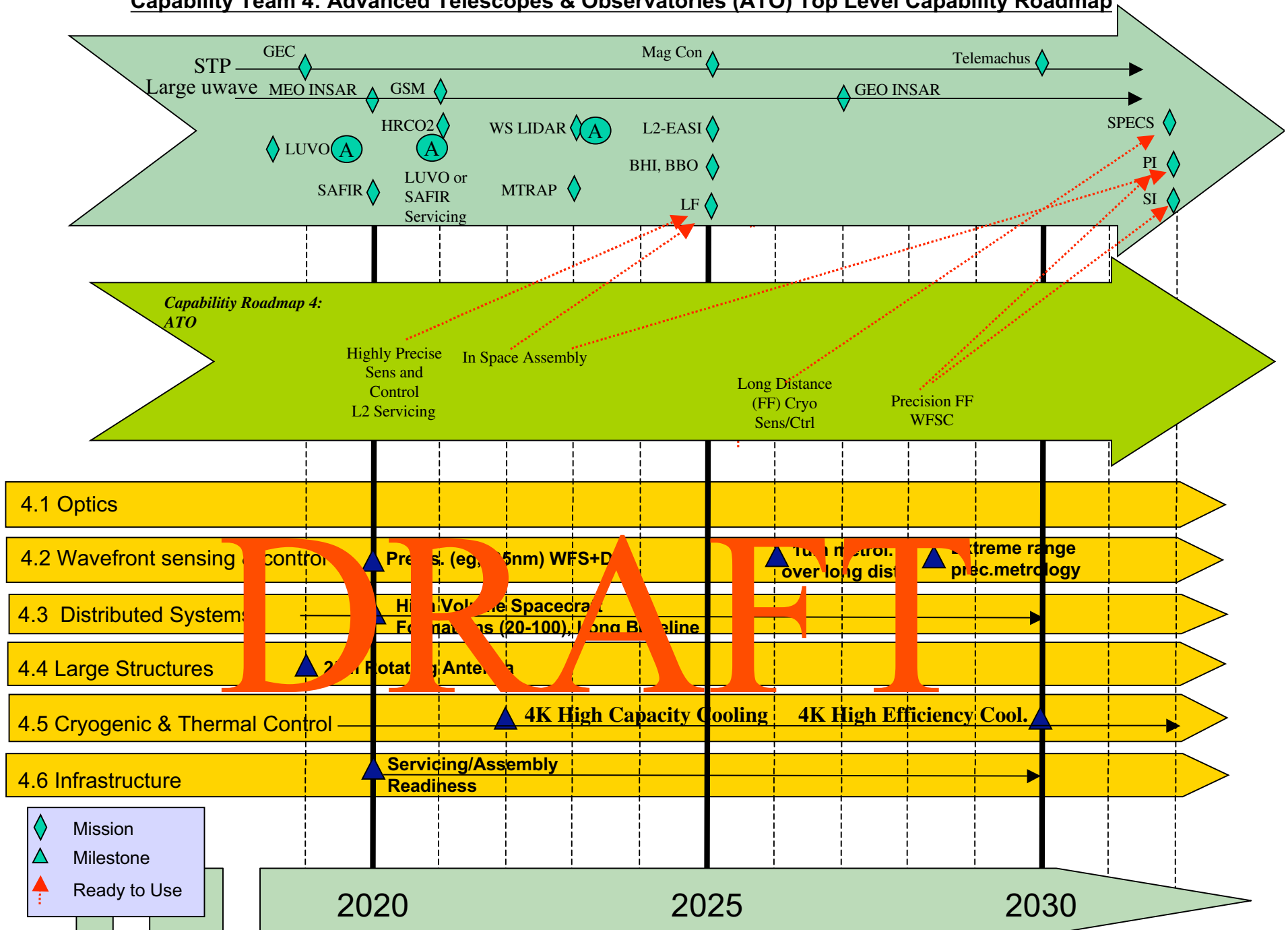
20+ Years

Note: Earth and Solar science are users of this technology but, with a few exceptions, not the drivers

# Capability Team 4: Advanced Telescopes & Observatories (ATO) Top Level Capability Roadmap



## Capability Team 4: Advanced Telescopes & Observatories (ATO) Top Level Capability Roadmap





## Closing Thoughts



- **Understanding of Search for Earth Like Planet Needs has Generally Been Good**
  - Good coordination through APIO Lead Coulter, Breckinridge, and GSFC Telescope Team
- In general, mission concepts for LF and PI are not well defined so technological needs have been primarily in the area TPFC, TPF1
- Alternative concepts for planet finding (eg, pinhole camera in space) are only captured in general terms
- Will be in position to share detailed draft roadmaps in March